PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

1838–9. No. 15.

Monday, 21*st January* 1839.

Lord GREENOCK, V. P., in the Chair.

The following Donations were presented :—

The Natural History of the Fishes of the Firth of Forth and Tributaries. By Richard Parnell, M. D., F. R. S. E.—*By the Author.*

The Laws of Harmonious Colouring, adapted to Interior Decorations, Manufactures, and other useful purposes. By R. D. Hay, House Painter.—*By the Author.*

The Silurian System, founded on Geological Researches in the Counties of Salop, Hereford, Radnor, Montgomery, Caermarthen, Brecon, Pembroke, Monmouth, Gloucester, Worcester, and Stafford; with Descriptions of the Coal-Fields and Overlying Formations; with a large separate Map. By Frederick Impey Murchison, F. R. S., F. L. S.—*By the Author.*

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences (1838, 2nd Semestre). Nos. 26, 27.—*By the Academy.*

Flora Batava, No. 116.—*By the King of Holland.*

The following communications were read :—

1. On the Colour of Steam under certain circumstances. By Professor Forbes.

The author accidentally remarked, that the colour of the Sun seen through vapour issuing from the safety-valve of a locomotive engine is deep red, exactly similar to that which a column of smoke or a smoked glass gives to it.

He next noticed that this colorific character of steam extended but a short way beyond the orifice, and that it gradually became more opake, and perfectly white like noon-day clouds, both for transmitted and reflected light. At moderate thicknesses, in this state, its opacity is complete.

These observations were fully confirmed by direct experiments on high-pressure steam, made at Glasgow in December last. At the moment of issuing from the steam-cock, it is perfectly transparent and colourless; at some distance from the orifice it becomes transparent and orange-red; but, still farther off, it is white, and merely translucent. These properties were traced in steam from a pressure above that of the atmosphere of 55 lb., down to an excess of only three or four; and as in all cases the redness of the transmitted light was more or less distinctly seen, (and an excess of 10 or 15 lb. does as well as any higher pressure), it was concluded that the effect of partial condensation in producing the phenomenon, would be rendered visible in great thicknesses of vapour of the lowest tension.

The great analogy of the colour of steam to that which the clouds assume at sunset, or distant lights in certain conditions of the atmosphere, lead the author to suggest this singular property of condensing vapour as the probable cause of those phenomena, of which no satisfactory explanation could be given whilst this fact remained unknown. The prognostics of weather derived from the colours of the sky also receive elucidation from the fact.

Judging from the similarity of colour of steam and that of nitrous acid gas, and the remarkable power of absorbing certain definite rays of the spectrum discovered in that gas by Sir David Brewster, the author thought it probable that similar lines might be discovered in the spectrum formed by light transmitted through steam, and that these might be found to coincide with the *atmospheric lines* of the spectrum noticed by the same philosopher. The experiment was made with great care, but the expected result has not been hitherto obtained. The general action of steam on the spectrum is to absorb the violet, blue, and yellow rays, finally leaving only the red and orange, with an imperfect green.

Since a portion of watery vapour in a confined space, originally transparent and colourless, may become, by mere change of temperature, first deep orange-red and transparent, and finally white and semiopake, the author notices another analogy with the singular effect of temperature in deepening the colour of nitrous acid gas, and thinks that these facts may one day throw some farther light on the difficult subject of the mechanical constitution of vapours, and particularly of clouds.

2. On the meaning of the Homeric terms θεμισ, δικη, τιμη, ποινη, with their more important compounds and derivatives. By the Venerable Archdeacon Williams.

Monday, 4th February.

Dr ABERCROMBIE, V. P., in the Chair.

The following Donations were presented :—

Tijdschrift voor Natuurlijke Gescheidenis en Physiologie. Uitgegeven door J. Van Der Hoeven, M. D., en W. H. De Vriese, M. D.—*By the Editors.*

First and Second Annual Reports, Laws, and Transactions of the Royal Botanical Society of Edinburgh.—*By the Society.*

Address of His Royal Highness the Duke of Sussex, K. G., &c. &c. President of the Royal Society, read at the Anniversary Meeting on Friday the 30th November 1838.—*By the Society.*

Proceedings of the Geological Society of London, 1838. No. 59. —*By the Society.*

Journal of the Statistical Society of London for January 1839.—*By the Society.*

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, 1839. 1er Semestre. Nos. 1, 2.—*By the Academy.*

Natuur-en-Scheikundig Archief, uitgegeven door G. J. Mulder en W. Wenkebach. 1837. St. 4.—*By the Editors.*

The following communication was read :—

The Colours of the Atmosphere considered with reference to a paper " On the Colour of Steam under certain circumstances," read at the last meeting of the Royal Society. By Professor Forbes.

The object of this paper was to develope an application of the fact communicated by the author on the 21st January. It was then remarked, that the discovery that steam in a certain stage of condensation is deeply red-coloured for transmitted light, seemed to offer a probable solution of a difficulty which has never yet been fairly met, namely, the red colour of clouds at sunset, and the redness of light transmitted through certain kinds of fogs.

A pretty full history of theories proposed to account for the colours of the atmosphere was first given; it was obtained in almost every case from an examination of the original authorities. These theories were reduced under three general heads, exclusively of that of Göthe, and of most writers before Newton, that the blue colour of the sky results from a mixture of light and shade; and that of Muncke, that that colour is merely *subjective*, or arises from an ocular deception. The remaining theories are:

(1.) That the colour of the sky is that transmitted by pure air, and that all the tints it displays are modifications of the reflected and transmitted colours. This is more or less completely the opinion of Mariotte, Bouguer, Euler, Leslie, and Brandes.

(2.) That the colours of the sky are explicable by floating vapours acting as thin plates do, in reflecting and transmitting complementary colours. This is the theory of Newton and most of his immediate followers, and more lately of Nobili.

(3.) On the principle of opalescence and of specific absorption, depending on the nature and unknown constitution of floating particles. This head is intended to embrace the various opinions of Melvill, Delaval, Count Maistre, and Sir D. Brewster.

To the last named philosopher, however, the merit is due of having conspicuously turned attention to the important, complex, and hitherto unexplained phenomena of absorption, which he has proved to be totally inconsistent with Newton's theory of the colours of Nature, (considered as those of thin plates); and he has farther demonstrated the inapplicability of it in the case of the colours of the atmosphere, by shewing that their constitution is wholly distinct from that which any modification of Newton's theory would assign, by a series of experiments of which as yet the results only are announced.

Since, then, the constitution of the atmospheric colours analyzed by the prism resembles that produced by absorption, the question is, To what medium are we to refer that absorptive action? Evidently not to pure air, since a distant light is red in a fog, and in clear weather white, or nearly so. The author is disposed to attribute the effect to the presence of vapour in the very act of condensation. This intermediate or colorific stage occurs between the colourless and transparent form of steam wholly uncondensed, and that which may be termed the state of *proximate* condensation in which it is seen to issue from the spout of a tea-kettle, when it is likewise colourless, but semiopake. During the transition, it was shewn in the former paper that steam becomes intensely red, and remains transparent. The absorptive action resembles then, so far, that of the atmosphere observed under certain meteorological conditions; the dark lines and bands noticed by Sir David Brewster in the atmospheric spectra have not been discovered, and so far the analogy is as yet imperfect.*

In applying this theory to the colours of sunset in particular, the author quotes many acknowledged facts to prove that the redness of the sky is developed precisely in proportion to the probable existence of vapour in that critical stage of condensation which should render it colorific. And he applies the same reasoning to account for the prognostics of weather, drawn from the redness of the evening and morning sky.

Monday, 18th February.

Dr ABERCROMBIE, V. P., in the Chair.

The following Donations were presented :—

Journal of the Asiatic Society of Bengal, No. 49. for January 1836. —*By the Society.*

Researches in Embryology. First Series. By Martin Barry, M. D. F. R. S. E.—*By the Author.*

Elements of Chemistry. By the late Edward Turner, M. D. 6th edition. Revised by Justus Liebig, M. D., and W. G. Turner, Ph. D. Part 3.—*By the Editors.*

---

* Some plausible reasons are assigned why these bands should not have appeared in the experiment as it was made, when steam in every stage of condensation must necessarily have been present; nor does it seem easy to devise a form of experiment free from this objection. A very important observation would be to examine the spectrum produced by a distant artificial light seen through a red fog.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, 1839. 1er Semestre. Nos. 3, 4.—*By the Academy.*

The following communications were read:—

1. Notice of some observations made during the Storm of January 1839. By John Scott Russell, Esq.

The author stated, that the paper consisted principally of communications made by members of this society, which had been placed in his hands. Many points in the statistics of the storm had been noticed with great accuracy; and it is important, in the present promising condition of our knowledge of the statistics and philosophy of this branch of meteorology, that such communications should be arranged and preserved, for the purpose of furnishing materials for its improvement. The author went on to explain the views of the nature of storms which had been successively propounded by Franklin, Espy, Redfield, and Reid. He then read various communications of observations, from Sir John Robison, Professor Christison, Mr Nichol, Mr Stevenson, Professor Wallace, Mr Hunter of Thurston, Mr Scott, Sir David Brewster, Mr Russell, Mr Bald, and other gentlemen, who had, with himself, taken an interest in the subject. The paper concluded with deductions of a general nature from the facts observed.

2. On Fresnel's Law for the Intensity of Reflected and Refracted Light. By Professor Kelland.

The object of this memoir was to remove from the molecular theory, difficulties in which the recent investigations of Mr Green appear to involve it. The question at issue is the ratio of the densities of the ether within and without a refracting medium. The usual mechanical hypotheses would appear to lead to the conclusion that the former density is the greater; whilst from the molecular hypothesis the latter appears to be the truth.

In the memoir of Mr Green appears a very strong argument for the hypothesis as originally stated by M. Fresnel, together with a statement which adds force to the objection, otherwise strong, against the molecular theory, viz. that vibrations are not necessarily transversal. It will be found in this memoir, that all the conclusions, and all the statements, of Mr Green, excepting only those which translate into language his resulting equations, are perfectly compatible with the molecular hypothesis, and may be deduced

from it as easily and with as little assumption as from the other. It is true the author has not endeavoured to give a closer approximation than that which M. Fresnel himself has exhibited to the vibrations which are polarized *in* the plane of incidence; but, as far as the approximation is carried, it gives precisely M. Fresnel's results. The want of experiments by which to test even the formulæ we do possess, is a sufficient reason for delaying farther investigations, which shall approach more nearly to the truth in all cases. In the mean time, it is of the utmost importance that M. Fresnel's empirical formula should be established, and his mechanical ones examined, by different processes.

Monday, 4th March.

Dr HOPE, V. P., in the Chair.

The following Donations were presented :—

Philosophical Transactions of the Royal Society of London for the year 1838. Part 1.

Proceedings of the Royal Society of London, 1837–38. Nos. 31, 32, 33, 34, and 35.

Astronomical Observations made at the Royal Observatory, Greenwich, in the year 1837, under the direction of George Biddell Airy, Esq. M. A., Astronomer-Royal.
By the Royal Society.

Transactions of the Cambridge Philosophical Society. Volume vi. Part 3.—*By the Society.*

Astronomische Nachrichten, Nos. 355 to 364.—*By Professor Schumacher.*

Annual Report of the Institution of Civil Engineers. Session 1839.—*By the Institution.*

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. 1839. 1er Semestre. Nos. 5, 6.—*By the Academy.*

Journal of the Statistical Society of London, No. 10, for February. —*By the Society.*

The Quarterly Journal of Agriculture; and the Prize-Essays and Transactions of the Highland and Agricultural Society of Scotland, No. 44, for March 1839.—*By the Society.*

A Geometrical Practical Treatise, named Pantometra, Longimetra, Planimetra, and Stereometra; by Thomas Digges, Esq. —*By P. D. Handyside, M.D.*

The following communications were read :—

Out

1. On a new Galvanic Battery, and an improved Voltameter. By Martyn Roberts, Esq. Communicated by Sir John Robison.

Electrical observers have experienced three important defects in the common galvanic trough battery, as constructed by Cruickshanks, namely, that the zinc is deposited on the copper plates, that the zinc plates become gradually covered with a coating of oxide of zinc, and that the hydrogen formed by the decomposition of water adheres in globules to the surface of the copper; the result of all which circumstances is, that the galvanic action quickly decreases in force. These inconveniences have been in part removed in the battery of Professor Daniell, in which the zinc plates are covered by an animal membrane, and sulphate of copper is substituted for acids to form an exciting solution. By the former precaution, the deposition of zinc on the copper plates is prevented ; and by the latter, hydrogen is no longer evolved so as to adhere to the copper plate. These contrivances, however, do not prevent the zinc plates from becoming gradually covered with oxide of zinc, as in the battery of Cruickshank; and, besides, the improvements made by Professor Daniell are attended with their own inconveniences in turn. Copper is gradually deposited on the zinc plates ; the animal membrane obstructs in some measure the free transmission of the electric current, and it is also apt to putrefy in no long time ; the cleaning of the plates is troublesome ; and the expense of employing a battery of considerable size must also be taken into consideration.

The author proposes to obviate all the inconveniences hitherto noticed, by resuming the original construction of Cruickshanks, rendering the plates circular and moveable on a common axle, which is turned slowly by a handle at one end of the trough, and attaching a rubber of cloth along the margin of the trough, by which the plates are constantly kept clear equally of metal, oxide, and hydrogen gas. By this contrivance, the power of a battery may be maintained without diminution for any length of time which is desired. He has found that an equal quantity of water may be decomposed in one fourth part of the time by his method, compared with what is required when the plates are left at rest, so that the battery is converted into the battery of Cruickshanks. Among other causes which have appeared to him to contribute to the sustained action of his battery, he has remarked, that considerable advantage seems to arise from the occasional exposure of the plates to the air.

The voltameter of the author consists of a tube bent like the letter U, which at one end has a glass reservoir attached to it, of the same capacity with the tube, and at the other graduated end has a stopcock to allow the gas to escape upon occasion, which accumulates at that end from the platinum wires evolving the gases at the bottom.

to 263

2. Notice upon the Alcoholic Strength of Wines. By Dr Christison.

Various accounts have been given of the alcoholic strength of wines by Mr Brande, Julia-Fontenelle, and others. The author has been engaged for some time in experiments for determining the proportion of alcohol contained in various wines of commerce, and also the circumstances which occasion a variety in this respect. The present paper is an interim notice of the results.

The method of analysis consisted in the mode by distillation, which was applied with such contrivances for accuracy that nearly the whole spirit and water were distilled over without a trace of empyreuma, and without the loss of more than between 2 and 6 grains in 2000. From the quantity and density of the spirit, the *weight* of absolute alcohol of the density 793.9, as well as the *volume* of proof spirit of the density 920, was calculated from the tables of Richter founded on those of Gilpin.

The author has been led to the general conclusion that the alcoholic strength of many wines has been overrated by some experimentalists, and gives the following table as the result of the investigations he has hitherto conducted. The first column gives the per-centage of absolute alcohol by weight in the wine, the second the per-centage of proof spirit by volume.

	Alc. p. c. by weight.	P. Sp. p. c. by volume.
Port—Weakest,	14.97	30.56
Mean of 7 wines,	16.20	33.91
Strongest,	17.10	37.27
White Port,	14.97	31.31
Sherry—Weakest,	13.98	30.84
Mean of 13 wines, excluding those very long kept in cask,	15.37	33.59

	Alc. p. c. by weight.	P. Sp. p. c. by volume.
Sherry—Strongest,	16.17	35.12
Mean of 9 wines very long kept in cask in the East Indies,	14.72	32.30
Madre da Xeres,	16.90	37.06
Madeira, all long in cask in East Indies — Strongest	14.09	30.80
Madeira, all long in cask in East Indies — Weakest	16.90	36.81
Teneriffe, long in cask at Calcutta,	13.84	30.21
Cercial,	15.45	33.65
Dry Lisbon,	16.14	34.71
Shiraz,	12.95	28.30
Amontillado,	12.63	27.60
Claret, a first growth of 1811,	7.72	16.95
Chateau-Latour, first growth 1825,	7.78	17.06
Rosan, second growth 1825,	7.61	16.74
Ordinary Claret, a superior "vin ordinaire,"	8.99	18.96
Rives Altes,	9.31	22.35
Malmsey,	12.86	28.37
Rudesheimer, superior quality,	8.40	18.44
Rudesheimer, inferior quality,	6.90	15.19
Hambacher, superior quality,	7.35	16.15
Giles' Edinburgh Ale, before bottling,	5.70	12.60
The same Ale, two years in bottle,	6.06	13.40
Superior London Porter, four months bottled,	5.36	11.91

In addition to certain obvious general conclusions which may be drawn from this table, the author stated, as the result of his experiments, that the alcoholic strength of various samples of the same kind bears no relation whatever to their commercial value, and is often very different from what would be indicated by the taste even of an experienced wine-taster.

Some observations were next made on the effect produced on the alcoholic strength of wines by certain modes of keeping or ripening them, more especially by the method employed in the case of sherry, madeira, and such other wines, which consists of slow evaporation for a series of years through the cask, above all, in hot climates. The researches made by the author on this head are not yet complete; but he is inclined to infer, from the experiments already made, that, for a moderate term of years, the proportion of alcohol increases in the wine, but afterwards, on the contrary, diminishes; and that the period when the wine begins to lose in alcoholic strength is probably that at which it ceases to improve in flavour. The increase which takes place at first in the alcohol of wine undergoing evaporation through the cask, appeared at first view parallel to the fact generally admitted on the authority of Söemering, that spirit becomes stronger when confined in bladder, or in a vessel covered with bladder, in consequence of the water passing out by elective exosmose.

The author, however, on repeating the experiments of Söemering, as related by various writers (for he could not obtain access to the original account of them), was unable, by any variation of the process he could devise, to obtain the results indicated by the German anatomist. Constantly the spirit, whatsoever its strength, whether proof spirit or rectified spirit, became weaker. It was observed at the same time, that, if the bladder containing spirit was enclosed in a confined space with quicklime, the spirit slowly became absolute alcohol of the density 796, in consequence of a permanent atmosphere of alcohol being speedily formed, while the watery atmosphere was absorbed by the quicklime as fast as it was produced. Subsequently it was proved that the bladder was not essential to the process ; for an open cup of rectified spirit, inclosed in a confined space with quicklime, to absorb the water which arose from the spirit, became in two months absolute alcohol of the density 796. Professor Graham of London some time ago proved the analogous fact, that spirit might be thus rendered pure alcohol in the air-pump vacuum. A vacuum, however, is, upon principle, as well as in fact, not necessary for the process ; it merely accelerates it. The new method is obviously applicable on the great scale for obtaining absolute alcohol, wherever time may be allowed.

Monday, 18*th March.*

Dr ABERCROMBIE, V. P., in the Chair.

The following Donations were presented :—

Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin. Aus dem Jahre, 1833.—*By the Academy.*

Uber die Länderverwaltung unter dem Chalifate. Von Joseph von Hammer.—*By the Royal Academy at Berlin.*

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, 1839. 1^{er} Semestre. Nos. 7, 8.—*By the Academy.*

The American Journal of Arts and Science. Conducted by Benjamin Silliman, M. D., LL.D. Vol. xxxv. No. 2, for January 1839.—*By the Editor.*

Journal of the Asiatic Society of Bengal for July 1838.—*By the Society.*

Natuur-en-Scheikundig Archief, uitgegeven door G. J. Mulder en W. Wenckebach. 1838. St. 1, 2.—*By the Editors.*

Tijdschrift voor Natuurlijke Geschiedenis en Physiologie. Uitgegeven door J. Van Der Hoeven, M.D., en W. H. De Vriese, M.D. Deel v. St. 3.—*By the Editors.*

Recherches sur l'Histoire Naturelle et l'Anatomie des Limules. Par J. Van Der Hoeven.—*By the Author.*

Tables of Logarithms; published by Taylor and Walton, booksellers, London.—*By the Publishers.*

Journal of the Statistical Society of London for March 1839.—*By the Society.*

The following communications were read:—

1. Notice respecting the Drying-up of the Rivers Teviot, Clyde, and Nith, and their tributaries, on the 27th November 1838. By David Milne, Esq.

The phenomenon was in the first instance described, and certain views were afterwards offered explanatory of it.

It appears that, betwixt 10 P. M. on the 26th November, and 6 A. M. on the 27th November, the channels of the Teviot, Clyde, and Nith, became nearly dry for a great part of their course, so that scarcely any current flowed in them. All the mills on the Clyde, as far down as several miles below New Lanark, were stopped from want of water. The Nith was nearly dry as far down as Enterkinefoot; and the mills on it, and on its tributaries, were stopped. This was the case also on the Teviot. The phenomenon was most strikingly manifested in the higher parts of the rivers, near their sources. The small streams from which they derive their supplies, were in general completely dried up. The rivers, in the lower parts of their course, were not entirely deprived of their current; nor were the rivulets, which there supplied them, nearly so much affected as the rivulets in more elevated districts.

The desiccation continued all the morning, forenoon, and part of the afternoon of the 27th November. When the current was restored, it returned not with a sudden rush, but gradually; nor when the current was restored, did the waters rise much above their ordinary level.

With reference to the cause of the phenomenon, it was stated, that various explanations had been suggested. Some persons had attributed it to the *high wind* obstructing the flowing of the current; others, to the *frost* in forming barriers of ice on the caulds or dam-heads; others, again, had suggested that the phenomenon might be connected with an earthquake. In support of this last theory, it was mentioned, that Professor Phillips had, in a recent work on geology, attributed to this cause the drying-up of the English rivers Trent and Medway, in the 12th century.

Mr Milne stated that he adopted none of these views, and that he thought the phenomenon might be accounted for by the united action of the frost and wind which prevailed during the night of the 26th November. After four o'clock that afternoon, the thermometer all over the south of Scotland sunk to 26°, at which point it remained for several hours. Accompanying this frost, there was a gale of wind from the east, which had the effect of very rapidly reducing the temperature of exposed and unsheltered spots. In this way, the small and shallow streams flowing in open drains and rivulets, or oozing through mosses and marshes in the hills, were soon frozen and arrested. But, on the other hand, larger bodies of water flowing rapidly in the main channels, at a lower level, and sheltered by high or wooded banks, could not in the same space of time lose enough of their temperature to be frozen. The waters thus ran off, without the usual renewal of supplies from the sources, so that the channel or bed of the river became speedily drained.

The reason of this phenomenon not happening more frequently appears to be, that there is very seldom a gale of wind in this country accompanied by a severe frost; and even on this occasion, the frost was not equally intense over the whole island. When a severe frost sets in, there is usually but little wind, so that the water in the *upper* parts of the river, is not liable to be cooled more rapidly than in the lower and more sheltered parts of its course. Though the sources will, in that case, to a certain degree, be frozen, and so, part of the usual supply cut off, the main body of the stream is frozen likewise, whereby the velocity of its current is diminished, by the obstruction of the ice at the bottom and at the surface of the current. So that if only half the usual supply is furnished to the river from its partially frozen sources, there will be no diminution in the quantity of water flowing in the main bed of the river, if it flows off with half its usual rapidity. This is the ordinary way in which frost acts on the rivers, in this country. But when, as on the night of the 26th November, the frost is accompanied with a strong and keen wind, which lasts for only a few hours, it freezes the water in the small rivulets near the sources of the rivers in high and exposed situations, whilst it has not time to freeze even the surface of the deeper and more rapid currents flowing in the lower parts of the rivers.

The easterly gale which, by its low temperature, produced this phenomenon, continued to blow until about 7 or 8 A. M. on the morning of the 27th November. The temperature of the atmosphere then underwent a sudden change, as indicated both by the barometer and the thermometer. This change was brought about by the advent of two storms, which came from southern latitudes, and one or perhaps both of which had, on the morning of the 27th, begun to affect the upper regions of the atmosphere, and load them with warm vapour.

2. Memorandum on the Intensity of Reflected Light and Heat.

By Professor Forbes.

At the meeting of the Society on the 4th February, I remarked, on the occasion of Professor Kelland's paper on the Intensity of Reflected Light, that it was almost without a parallel in science, that a quantitative physical law like that of the intensity of the reflection of light at different angles, should have first been divined by the rare sagacity of Fresnel, and confirmed by the very different but elaborate mathematical investigations which Mr Green of Cambridge and Professor Kelland have applied to the subject, whilst scarcely any attempt has been made towards its verification by direct experiment.

Some critical cases for polarized light were indeed assumed as the basis of the original formula; and M. Arago has confirmed it by one or two intermediate photometrical experiments: but the chief evidence for the truth of this remarkable law rests on the indirect observation of the change of the plane of polarization of an incident ray after reflection.

It occurred to me, about the end of 1837, that the anomalies of photometrical observations being nearly as unsatisfactory as ever, some light might be thrown upon this important subject by ascertaining the law in the case of heat, the intensity of which we have no difficulty in measuring. And since the discovery in the case of heat, of refraction, single and double, of polarization, of total reflection, and the change it produces on polarized light, as well as the change of the plane of polarization by simple reflection, there seems the greatest reason to suppose that the laws of reflection for heat and light, if not identical for both, would be connected by some simple analogy.

Accordingly, during the month of December 1837, I made some preliminary observations, which encouraged me to proceed. It appears to me, from those observations, that the quantity of heat reflected from different transparent bodies is independent, or nearly so, of the nature of the source of heat, and the diathermancy of the reflecting body, and that at 55° of incidence the intensity of reflected heat is nearly that which Fresnel's theory gives. The substances, however, were not all prepared so as wholly to exclude the action of second surfaces.

I have this winter resumed the subject. I have had an apparatus constructed for securing sufficient accuracy in determining the angle of incidence, and I have used reflecting surfaces, both transparent and metallic; the former are wedges of plate-glass, by means of which reflection from the first surface only may be observed, and the latter are plane specula of steel and silver. The prosecution, however, of these apparently simple experiments has been attended with unforeseen difficulties; and although the relative proportions of heat at different angles of incidence are now pretty well determined for glass in several cases, I am not prepared to say whether the absolute amount is exactly the same as Fresnel's formula would give, assigning to heat its proper refractive index. It is satisfactory, however, to know, that the approximation to it is much greater than direct photometrical measures have yet given, with the single exception of two experiments of M. Arago already referred to; and that I have reason to believe that the experimental law which Mr Potter has given from direct observation in the case of light, represents my results much less accurately than the theory of Fresnel.

With respect to reflection at the metals, I believe I may assert that I have verified the remark of the last named ingenious observer, that metallic reflection is *less* intense at the higher angles of incidence. I have attempted to ascertain whether it reaches a minimum, and then increases up to 90° of incidence, as Mr Maccullagh supposes, but I have not obtained decisive results. The quantity of heat reflected by the metals is so much greater than Mr Potter's estimate for light, as to lead me to suspect that his photometric ratios are all too small, which would nearly account for their deviation from Fresnel's law.

The most complete verification of Fresnel's law would be found in observations made on heat polarized in opposite planes. These I have attempted, and, so far as they go, they seem to confirm the analogies of heat and light. But the intensity is so much reduced in the process of polarizing, that I fear we must wait for yet more delicate instruments to measure it. In the mean time I may state the method which I propose to employ.

When heat is polarized by transmission through inclined mica-plates, the polarization is *incomplete ;* but if the plates be inclined at the polarizing angle, the transmitted heat is undoubtedly composed of a portion p polarized (in a plane which we will call $+$), and a portion $1 - p$ unpolarized. This latter part philosophers are content to consider as compounded of a part $\frac{1-p}{2}$ polarized $+$, and an equal part polarized $-$. Now, let the intensity of reflected heat polarized in the plane of reflection (or $-$), and that perpendicular to it (or $+$), be represented by the following Table, which contains the quantities to be *found.*

Monday, 1*st April.*

Dr HOPE, V. P., in the Chair.

The following Donations were presented :—

Memoirs of the Royal Astronomical Society. Vols. 9 and 10.—*By the Society.*

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, 1839. 1$^{\text{er}}$ Semestre. No. 9.—*By the Academy.*

Transactions of the Society for the Encouragement of Arts, Manufactures, and Commerce. Vol. lii. Part 1.—*By the Society.*

Annuaire de l'Académie Royale des Sciences et Belles Lettres de Bruxelles, pour 1839.

Bulletin de l'Académie Royale des Sciences et Belles Lettres de Bruxelles. 1838. Nos. 9, 10, 11, 12.

Nouveaux Mémoires de l'Académie Royale des Sciences et Belles Lettres de Bruxelles. Tome xi.

Mémoires Couronnés par l'Académie Royale des Sciences et Belles Lettres de Bruxelles. Tome xiv. Premiere partie. *By the Academy.*

Annuaire de l'Observatoire de Bruxelles pour l'an 1839, par le Directeur A. Quetelet.—*By the Author.*

Résumé des Observations Météorologiques faites en 1838 à l'Observatoire de Bruxelles, par A. Quetelet, Directeur de cet Etablissement—*By the Author.*

Journal of the Asiatic Society of Bengal for August 1838.—*By the Society.*

Astronomical Observations made at the Royal Observatory, Edinburgh. By Thomas Henderson, F. R. S. E. and R. A. S. Vol. ii. for the year 1836.—*By the Royal Society of London.*

Journal of the Royal Geographical Society. Vol. ix. Part 1.—*By the Society.*

Geometrical Theorems and Analytical Formulæ, with their application to the Solution of certain Geodetical Problems. By William Wallace, LL.D., &c.—*By the Author.*

The following communications were read:—

1. On the Theory of the Motion of Waves. By Professor Kelland.

The author proposes, in a series of memoirs on this subject, to investigate the different problems of Hydrodynamics, in a manner which shall carry theory along with experiment. From the great attention that has been of late years bestowed on the question of the motion of the tide-wave, any mathematical investigation which does not assume some process of approximation, is extremely interesting. Whilst the more recondite problems of motion derived from impulses, &c. have been carefully examined by the greatest philosophers of the present day, the more simple and easy ones have been left almost untouched. This may be accounted for by the elegance of the process in the former case compared with that to be pursued in the latter; but still it is remarkable that the most useful speculations, in a theoretical point of view, should excite so little attention. The author proposes to supply the deficiency here felt, by examining in detail simple problems of wave motion, in every possible form of canal or channel, and intends to apply the results to the motion of the tide-wave, and similar problems. The results which he has already laid before the Society, are merely the introductory steps, comprising the discussion of the general form of uniform and perfect wave-motion, and an approximative solution of the problem of solitary translation. In other memoirs, he hopes to apply similar processes to incipient motion, retarded motion, and the combination of extraneous forces with internal cohesion.

2. On a New Method of shewing the Unequal Expansion of Crystals. By Professor Forbes.

This method is founded on the expedient devised by Mitscherlich, of obtaining two images of a minute distant object from a section of a hemitrope crystal of selenite, which is flat when cold, but is composed of two inclined surfaces when heated. By throwing the sun's image, reflected from such a surface, on a distant wall, the gradual formation of the double image during heating may be seen by any number of persons.

TABLE I.

Incidence.	Reflected Rays Polarized.	
	+	—
0°	a_0	b_0
10	a_1	b_1
20	a_2	b_2
&c.	&c.	&c.

Also let the quantities of heat actually *observed* to be reflected after *incomplete* polarization by passing through a mica bundle, be the following:

TABLE II.

Incidence.	Polarizing Plane of Mica Bundle.	
	+	—
0°	A_0	B_0
10	A_1	B_1
20	A_2	B_2
&c.	&c.	&c.

Now, the quantities A and B will be thus composed: The quantity of heat transmitted by the mica bundle and incident on the reflecting surface contains, when the plane of polarization is perpendicular to the plane of reflection, a portion of heat $p+\frac{1-p}{2}$ polarized +, and a portion of heat $\frac{1-p}{2}$ polarized —; let these quantities be m

and n; then $m + n = 1$. Now, let the plane of polarization be turned round 90°; then the part polarized in the plane of reflection will now be m, and that perpendicular n. So that the heat is first composed of a part m reflected according to the law of a in Table I., and a part n reflected according to the law of b; and then the converse; so that

$$A_q = m\,a_q + n\,b_q$$
$$B_q = n\,a_q + m\,b_q$$

Hence $A_q + B_q = a_q + b_q$, as it evidently ought, and

$$A_q - B_q = (m - n)\,(a_q - b_q)$$

Hence *the differences of the columns in Table II. are in a constant ratio to the differences of the columns in Table I.*; and as Table I. may be computed from Fresnel's formulæ

$$\frac{\tan^2(i - i')}{\tan^2(i + i')}, \text{ and } \frac{\sin^2(i - i')}{\sin^2(i + i')},$$

the agreement or discrepancy will be apparent, and the coefficient $(m - n)$ will indicate the polarizing power of the plates. Also, since the sum of the numbers must be the same for both tables, a single comparison would suffice to determine the index of refraction, which must be assumed in computing the first table.

3. On the Diminution of Temperature with Height in the Atmosphere at different Seasons of the Year. By the same.

The results communicated to the Society were obtained from nearly five years of simultaneous observations, made twice a-day at Colinton and at the Bonally reservoir five miles south-west from Edinburgh. The height of the former station above the level of the sea is 364 feet, of the latter 1100 feet exactly; the difference 736 feet. The mean annual difference of temperature amounted to 3°.22, giving 229 feet of ascent for a diminution of temperature of 1° Fahr. The influence of the seasons is briefly shewn by the following numbers:

Months, .	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean Diff. of Temp.	2.10	2.31	3.61	4.60	4.69	3.79	3.22	3.74	3.12	3.13	1.90	2.49
Feet for 1°,	351	319	204	159	157	194	229	197	236	235	387	296

That the decrement of temperature is most rapid in summer, and least so in winter, has been long known. Its highest value appears to occur in April or May, and its lowest about November. These results are confirmed by the comparative observations made at Geneva and the Great St Bernard, where the difference of elevation is no less than 6800 feet. The reason of this the author conceives to be the following. When we compare the curves of annual temperature at the lower and higher stations, we find the following differences. (1.) The curve at the higher station is in every point *lower* than that at the other station. (2.) It is *flatter*; the annual range being less. This causes the difference of maxima to exceed the difference of minima. (3.) The curve at the higher station is *shifted*, so that its maximum and minimum occur later. This causes the difference between the two curves to attain a maximum during their rise, and a minimum during their decline, which corresponds to the fact, and is easily explained on known meteorological principles.

Monday, 15th *April.*

Lord **GREENOCK** in the Chair.

The following Donations were presented:—

Bulletin de la Société de Géographie. Deuxieme serie. Tome x. —*By the Society.*

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, 1839. 1er Semestre. Nos. 10, 11, 12.—*By the Academy.*

Report on the Geology of Cornwall, Devon, and West Somerset. By Henry T. De La Beche, F.R.S., &c.—*Presented by the Lords of the Treasury.*

Flora Batava, No. 117—*By the King of Holland.*

Journal of the Statistical Society of London, No. 12, for April.—*By the Society.*

Herniarum Corporis Humani Tabulæ Anatomico-Pathologicæ ac Chirurgicæ quas edidere Professores Imperatoriæ Medico-Chirurgicæ Academiæ Petropolitanæ Christianus Salomon Petrus Savenko.

Eliæ Buialsky Tabulæ Anatomico-Chirurgicæ, Operationes Ligandarum Arteriarum Majorum exponentes.

By the Imperial Medico-Chirurgical Academy of St Petersburgh.

The following communications were read:—

1. Notice respecting the relative Voltaic agency of Circuits of Copper and Zinc, and Zinc and Iron. By Martyn Roberts, Esq. Communicated by the Secretary.

While conducting some galvanic experiments, the author accidentally used an iron-wire as a positive electrode, and was surprised to find it was not oxidated, but, on the contrary, retained its original brightness, and gave out oxygen-gas from water placed under its action, in the same quantity as a platinum electrode would have done in the same situation.

Struck by this fact, he followed it up by a course of experiments, and arrived at the conclusion that iron is in a singularly anomalous electric condition, being positive when compared with copper, and yet far more highly negative than copper when compared in their electric relation with zinc; and that although copper and iron form a galvanic combination in which the iron is positive to the copper, yet, when iron is associated with zinc as a galvanic pair, it produces a more powerful current of electricity than a galvanic pair of equal-size, consisting of copper and zinc.

A brief notice of illustrative experiments was given.

The first experiments were made on the 1st January of the present year. A galvanic pair, iron and zinc, immersed in dilute sulphuric acid, was connected with two cups of a differential galvanometer; another pair, copper and zinc, immersed in acid of the same strength as that in which the iron and zinc was plunged, was connected with the opposite cups of the galvanometer, both pairs being of precisely the same area. The power of the iron and zinc pair to deflect the needle of the galvanometer, exceeded that of the copper and zinc pair by 25°.

The author then constructed two small experimental batteries, each consisting of ten pairs, fitted upon Wollaston's plan, the zinc plates in both of which were 2½ inches square. One of the batteries was a combination of iron and zinc, the other a combination of copper and zinc. With the battery of iron and zinc, a cubic inch of the mixed gases was decomposed in seven minutes, and with the copper and zinc battery the same quantity required thirty-three minutes for its formation. With the former, four cubic inches were produced in 104 minutes, when the action ceased from neutralization of the exciting acid; with the latter, one cubic inch and a half were formed in 125 minutes, and the acid liquor became neutral.

This singular result appears to the author likely to lead to some new law of electricity, and tends to overturn the present ideas of galvanic excitation. An investigation of the details is promised at some future period.

2. Investigation of analogous properties of Co-ordinates of Elliptic and Hyperbolic Sectors. By W. Wallace, LL.D., Emeritus Professor of Mathematics, University of Edinburgh.

The object of this paper is to investigate, for the ellipse and hyperbola, a series of propositions analogous to those which, in the circle, constitute the *calculus of sines.*

Any diameter of an ellipse, or a transverse diameter of a hyperbola, is expressed by a, its conjugate diameter by b, and the ratio of these diameters, viz. $\frac{a}{b}$, by c. The nature of the curves is expressed by this formula, $x^2 + cy^2 = a^2$. In the ellipse, c has the sign $+$, but in the hyperbola the sign $-$.

Any two sectors of the curves contained between any diameter of an ellipse, or a transverse diameter of a hyperbola, and any other diameter, are denoted by α and β, and sectors equal to their sum or difference by $\alpha + \beta$ and $\alpha - \beta$. The co-ordinates of the vertices of the diameters which bound a sector α, are denoted by $f(\alpha)$, and $F(\alpha)$. These co-ordinates being considered as functions of the sectors, the letters f and F are used as characteristics of the functions; when applied to the circle, $f(\alpha)$ is the *cosine* of α, and $F(\alpha)$ its *sine.* The expressions for $f(\alpha + \beta)$, $f(\alpha - \beta)$, $F(\alpha + \beta)$, $F(\alpha - \beta)$, the origin of the sectors being any diameter of the ellipse, are investigated, and the results tabulated.

Supposing the sectors to be contained between a, the transverse axis of an ellipse or hyperbola, and any oblique diameters, then putting e for the eccentricity of the curve, the formulæ found are these:

$$af(\alpha + \beta) = f(\alpha)f(\beta) - \frac{a^2}{a^2 - e^2} F(\alpha) F(\beta), \dots\dots\dots\dots (1)$$

$$a F(\alpha + \beta) = F(\alpha) f(\beta) + f(\alpha) F(\beta), \dots\dots\dots\dots\dots\dots\dots (2)$$

$$af(\alpha - \beta) = f(\alpha) f \beta + \frac{a^2}{a^2 - e^2} F(\alpha) F(\beta), \dots\dots\dots\dots (3)$$

$$a F(\alpha - \beta) = F(\alpha) f(\beta) - f(\alpha) F(\beta). \dots\dots\dots\dots\dots\dots\dots (4)$$

Proceeding from these formulæ, a theory of the functions $f(na)$, and F(na), analogous to that of the functions cos (na), and sin (na), in the calculus of angles, is established entirely by the ordinary algebraic analysis.

3. On the Newer Tertiary or Pliocene Deposites of Scotland. By James Smith, Esq. of Jordanhill.

Mr Smith of Jordanhill stated the general results of his observations on the newest tertiary or pliocene deposites of Scotland. In every one of the maritime counties, elevated marine beds containing shells, of which about one-tenth are no longer to be found in the British seas, have been discovered. Some of the shells appear to have become altogether extinct, others occur in crag and Sicilian tertiary beds, and others in the Arctic seas,—indicating that the climate was probably colder at the period of their deposition.

The so-called submarine forests, and till or diluvium, lie under these deposites, and are therefore of still greater antiquity. Mammalian remains have been discovered in them, all of which appear to differ from recent species.

Date

4. On certain circumstances affecting the Colour of Blood during Coagulation. By Dr P. K. Newbigging. Communicated by Professor Forbes.

To 275

The author described in this paper certain anomalous appearances presented by venous blood when left in contact with coloured porcelain. When blood drawn from a vein is either allowed to coagulate in a porcelain cup, or after coagulation is left in it for some hours, the dark purple tint characteristic of venous blood is found to be altered to the bright arterial hue, wherever it was in contact with any elevated device of the green colour, which is communicated by means of protoxide of chrome. In one instance the same effect was produced by a device of a crimson tint; but in more than sixty trials with this and every other variety of colour used in ornamenting porcelain, the author could observe no such effect as was invariably produced by patterns of a green tint. The effect was scarcely apparent, if the pattern was not somewhat elevated. Mere elevation of the porcelain, however, is not the cause of the change of colour. Adhesion of a little oxygen of the air to the surface of the pattern is not its cause; for no change is produced by the green devices of porcelain on a gelatinous mass of gelatin and protoxide of iron, which is quickly rendered brick-red wherever it is put in contact with oxygen. Neither is the change owing to any peculiar arrangement of the molecules of the blood, because it is produced equally on coagulated blood and upon that which is allowed to coagulate in the cup. The author is compelled, therefore, simply to record the fact, that objects on porcelain of a green colour produce their impression, and this with extreme accuracy, on venous blood left in contact with them, and that the change of colour which takes place seems identical with the florid hue occasioned by arterialization of the blood from ordinary causes.

5. On two Storms which passed over the British Islands in the end of November 1838. By David Milne, Esq. Advocate.

It was stated, that the first indication of the advent of these two storms to the British islands was given by the barometer. On the 25th and 26th November, the barometer in all parts of the United Kingdom began to sink; and it is important to observe, that, not only when this sinking began, but likewise for nearly two days after, the wind was blowing E. or NE., and was accompanied by a severe frost, circumstances which of themselves cause the mercurial column to rise.

The exact hours on the 25th and 26th November at which, in different places, the barometer began to sink were noticed, from which it appeared that the sinking took place in the south part of the United Kingdom about five or six A. M. on the 25th, and in the north of Scotland about two or three in the morning of the 26th.

I. Now, as the first storm did not reach England, or, in other words, that part of the surface of the globe, till about noon on the 26th, and the north part of Scotland till the night of the 27th or morning of the 28th, it is obvious that the upper regions of the atmosphere were, in the British islands, affected before the lower regions by a period of about thirty hours. It follows, that the *upper* part of the storm preceded the *lower* part, in its progress over the surface of the globe.

This first storm commenced at Cork on the 26th, at 11 A. M.; at Cornwall, about noon; at Dublin, about 3½ P. M.; at the Isle of Man, early in the morning of the 27th; at Lismore, on the night of the 27th; and Cape Wrath, not till the 28th November.

The wind at all these places, on the commencement of the storm, blew from SE. or SSE.; it afterwards veered to SW., and on the cessation of the storm it was blowing from NW. The veering to SW. took place in Cornwall during the *forenoon* of the 27th; it took place in Dublin in the *evening* of that day.

Heavy gusts came from a point due west, or rather to the north of west, shortly before the cessation of the storm. These were felt in Cornwall in the *afternoon* of the 27*th;* they did not commence at Pladda (off the coast of Ayrshire) till the *night* of the 28*th* November.

From these and other similar data, it was concluded, that the storm moved progressively in a N.NE. direction, at the rate of ten or eleven miles an hour.

The progress of this storm from southern latitudes was next described, by reference to various places both on sea and land, as far south as Gibraltar, at all of which it had been severely felt. On the 22d and 23d, a storm from the S. was experienced at the mouth of the Garonne. Off the NW. coast of Portugal, three vessels were dismasted by a hurricane on the 22d; at Gibraltar, there was a storm on the 21st November. It was most probably one and the same storm which passed over all these places, beginning at Gibraltar on the 21st, and reaching the British islands on the 26th November;—seeing it would arrive there at the very time that the first storm begun in England, and had the same direction and rate of movement.

Some circumstances were stated, shewing that this storm had probably a rotatory as well as a progressive motion. These were, (1.) the great velocity of the wind in the storm, compared with the actual motion of the storm; (2.) the veering of the wind in the storm from SE. to NW.; (3.) the greater violence of the gusts from S. and SW.,—the progressive and rotatory motions then coincided.

II. The second storm begun on the SW. coast of Ireland about 2 A. M. on the 28th; at Cork, about 3 or 4 A. M.; Cornwall, about 5 A. M.; Plymouth, about 9 A. M.; and Fairnborough (near Bagshot), about 10 A. M.

At all these places there was, during the previous night, a calm, or light airs from the westward.

This storm reached Dublin about 1 P. M. on the 28th; Glasgow, about 3 P. M.; and Kirkaldy, between 4 and 6 P. M. It travelled northward, therefore, at the rate of about twenty miles an hour.

This inference was corroborated by the periods at which, in different places, the wind in the storm veered from SE. to SW. This veering, which took place in Cornwall about *noon* on 28*th*, did not take place at Kirkaldy till the *afternoon* of the 29*th*.

A separate and still more striking confirmation is afforded by the period when the barometer reached its lowest point at different places. Its greatest depression in the Bristol Channel occurred at noon on the 28th; in Edinburgh and Glasgow, at 12 h. 16 m. on the 29th; in Kinfauns Castle (Perthshire), at 8½ P. M. on the 29th.

That this storm had, like the previous one, a progressive motion to N.NE., there can be no doubt; and from its moving in nearly the same track, but travelling with twice the rapidity, it overtook the first storm about the middle of Scotland; in consequence of which, the indications of two separate storms became indistinct in these northern parts.

There were many circumstances shewing that this second storm had a rotatory as well as a progressive motion, and that the centre of the stormy circle travelled along a path considerably to the west of the British islands. (1.) One of these was the greater magnitude of the angle made by the wind in veering, and the greater rapidity with which the veering was effected, in places situated to the west, than in places situated to the east. At Limerick, the wind veered 158° in 28½ hours; at Penzance, 112° in 24 hours; at Greenwich, 79° in 24 hours; at Kinfauns, 90° in 24 hours. (2.) When the storm ceased, the wind was blowing more from the north in places situated to the west. On the west coast of Ireland, it was blowing W. or W.NW.; in the south-west of Scotland, and at Holyhead, it was blowing W.SW. or SW. (3.) The barometer was lowest towards the west; and by classing together those places where the depression was the same, it appeared that these places lay in lines or zones running in a N.NE. direction, in each of which the barometer stood at a lower level in proportion as its situation was toward the west. In London and Greenwich, the barometer stood at its greatest depression at 28.70; at Limerick, it stood at its greatest depression at 27.49, both observations being reduced for height. (4.) It was found that a storm had traversed the eastern part of the Atlantic, moving in a N.NE. direction, having been felt at the Garonne on the 27th, 28th, and 29th; at Oporto, from the 24th to the 27th; at Lisbon, on the night of the 23d. It appeared that several vessels in the middle of the Atlantic had, on the 28th, been dismasted by a NW. gale, whilst the Great Western steamer, some degrees to the NW. of these ships, though on that day and the next she experienced no gale, encountered a heavy swell from the N.NE.

It appeared from these, and some other data which were detailed, that this storm moved N.NE. over the Atlantic, at the rate of about twenty miles an hour; that it had also a rotatory motion, and that the centre of the circle passed very considerably to the west of the British islands, so that it was only a segment of the storm which swept over these islands.

It was mentioned that, before the most furious part of the gale reached England, and before the barometer reached its greatest depression, a storm-wave had entered the Irish and Bristol Channels, and caused, in most of the harbours there, on the night of the 28th November, an unusually high tide.